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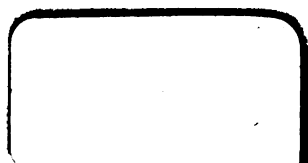
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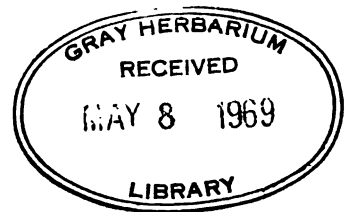
THE BIOGEOGRAPHY OF THE NORTHERN GREAT PLAINS

BY
STEPHEN S. V^ISHER, Ph.D.

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THE GEOGRAPHICAL REVIEW

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THE BIOGEOGRAPHY OF THE NORTHERN GREAT PLAINS*

By STEPHEN S. VISHER, Ph.D.

The Northern Great Plains region (map, Fig. 1) displays a rather monotonous and uninviting aspect. The characteristic vegetation of millions of acres is short grass, low herbs, and stunted shrubs, nearly all of which appear dead during more than half the year. Animal life, too, is rarely conspicuous and in general seems almost wanting. The signs of human occupation are few and not uncommonly of a doleful sort, unattractive shacks, stunted crops, or poorly constructed barbed-wire fences.

The region is far more attractive to the geographer who appreciates that it contains many evident and important responses to geographic conditions.¹ The fairly high latitude, location to the leeward of a lofty mountain range, the irregular and meager precipitation, and the rather uneventful geologic history of the region combine to produce the more direct influences: the amount of moisture and heat content of the soil, subsoil, and air, the compactness of soil and subsoil, the exposure of the surface to sun and wind, and the drainage. These factors are few in number and fairly uniform over large areas. They have acted as the chief selective agents in barring most of the many species which, for topographic reasons, have found it easy to attempt to establish themselves on the steppe.

Because of the comparatively simple geographic conditions, the paucity of species, the simplicity of structure of the plants, the unusual opportunities for field work and the many striking "adaptations" in plants and animals, this region appears especially suitable for a study in biogeography.

* This study is based on several summers' field work in South Dakota, eastern Montana and Wyoming, North Dakota, and northern Nebraska. The western two-thirds of South Dakota is the area from which most of the data were obtained, but the related biogeographic conditions in neighboring states are also included.

Much of the field work was done under the auspices of the South Dakota Geological and Natural History Survey. The writer wishes also to acknowledge assistance from Professors R. D. Salisbury and Henry C. Cowles, of the University of Chicago, and Victor E. Shelford, of the University of Illinois.

¹ A suggestive general discussion of the environmental reactions, plant, animal, and human, in the Northern Great Plains region, which is, however, not free from errors in generalization, is to be found in Wallace Craig: North Dakota Life, Plant, Animal, and Human, *Bull. Amer. Geogr. Soc.*, Vol. 40, 1908, pp. 321-332 and 401-415. S. S. Visher: Notes on the Significance of the Biota and Biogeography, *Bull. Amer. Geogr. Soc.*, Vol. 47, 1915, pp. 509-520, also treats of various environmental reactions in the Northern Great Plains.

GENERAL GEOGRAPHIC CONDITIONS OF THE STEPPE

The greater part of the Northern Great Plains is a semi-arid grassland, large areas of which are dominated by short grasses and bunch grasses, and smaller areas by low shrubs. In the following discussion, the term steppe is used for these three semi-arid plant formations, the sub-humid prairie not being included.

The climatic conditions of the Northern Great Plains are severe. The rainfall is irregular in its distribution. It sometimes falls in hard showers and occasionally is accompanied by hail. Slight showers may bring the only precipitation received during long periods. Droughts of shorter (a few weeks) or longer (two or three seasons) duration are not rare. Ordinarily, about four-fifths of the total precipitation (which averages about 15 inches per year) takes place in the five growing months (April to August). The rest of the year is conspicuously dry. The relative humidity of the atmosphere in the steppe is low and the rate of evaporation high. In much of the area, the possible rate of evaporation is from two to five times the average rainfall.

The extreme yearly range of temperature is almost 150° F., and the daily range frequently 50°. The seasons are irregular as to time of occurrence, and summer maxima of 100° and winter minima of -40° are not rare. Freezes which terminate

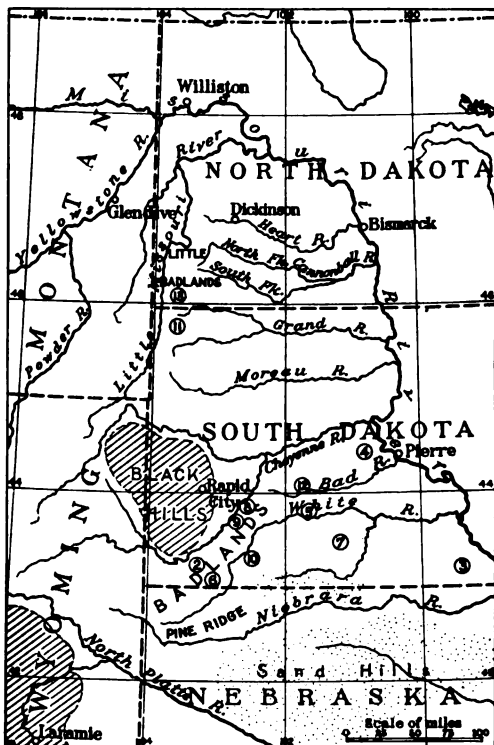


FIG. 1—Sketch-map of the part of the Northern Great Plains especially studied. Scale, 1:9,000,000.

The numerals enclosed in circles correspond to the figure numbers and indicate where the photographs were taken.

most of the vegetative activity sometimes occur as early as mid-September and as late as May, and less severe frosts as early as the beginning of September and as late as early June.

The wind velocities are seldom high, but an 8 to 12 mile breeze is almost constant during the daytime. In the summer, such winds may be exceedingly hot and, if the air is very dry, may wither the vegetation. When driving dry snow the high winds of winter are peculiarly severe.

There is little protection from the heat of the sun for the plants or for

non-burrowing animals, except those which can be sheltered by low shrubs, which are rarely dense, the larger herbs, and the very low cliffs ("cut banks") which are found here and there along the valleys. Dark, cloudy days are infrequent. With respect to conditions of light the steppe approaches the desert.

THE MORE CONSPICUOUS PLANTS AND ANIMALS²

While the intimate relations of the plant and animal populations of the Northern Great Plains to the physical conditions of the region are the chief theme of this paper it is necessary to introduce the main topic by a few summary paragraphs which list the characteristic forms of life in each group.

PLANTS³

The predominant plants are the grasses;⁴ chief among these are grama grass, buffalo grass, wheat grass, and wire grass.

Plants of the composite family occupy second place. In the summer they are more conspicuous in many places than the grasses. Nearly a third of the common species belong to this family. The most noteworthy are:⁵ blazing-star, golden-rod, cone-flower, golden aster, white aster, resin or gumweed, nigger-head, worm-wood, sage, prairie-sage, sunflower, yarrow, prairie-pink, fleabane, and two with no common names, *Sideranthus*, *Actinella*.

The legume family ranks third. It includes some of the more abundant plants of these plains, notably⁶ the prairie-clover, lead-plant, Dakota vetch, buffalo-bean, loco, lupine, and wild alfalfas (*Psoralea*) (Fig. 2).

Abundant monocotyledons, other than the grasses, are the wild onion and prairie lilies.⁷ Dicotyledons other than the composites and legumes are numerous. There are several crucifers (mustard family), including⁸ shepherd's purse, wall-flower, and *Lesquerella*, *Sophia*, *Arabis*. Several sorts of

² The author is under obligations to the U. S. Biological Survey for determining the varieties of numerous mammals and a few birds; to P. A. Rydberg and Aven Nelson for naming plants; to Alexander Ruthven for determining reptiles and amphibians; and to L. P. Morse, W. M. Mann, and others for naming insects.

³ The more important treatments of the plant ecology of the Northern Great Plains are R. Pound and F. E. Clements: *The Phytogeography of Nebraska* (Lincoln, 1900); H. L. Shantz: *The Short Grass Formation of Colorado*, U. S. Dept. Agric. Bull. 201 (Washington, 1911); R. J. Pool: *A Study of the Vegetation of the Sandhills of Nebraska*, Geol. and Nat. Hist. Surv. of Minnesota Botanical Studies, Vol. 4, Part 3, pp. 189-312 (Minneapolis, 1914); and S. S. Visser: *The Biology of South-Central South Dakota*, *South Dakota Geol. and Biol. Surv. Bull. No. 5*, pp. 61-130 (Vermillion, 1912), and *The Biology of Harding County, Northwestern South Dakota*, *South Dakota Geol. Surv. Bull. No. 6*, pp. 11-103 (Vermillion, 1914).

⁴ *Bouteloua oligostachya*; *Buchloe dactyloides*; *Agropyron tenerum*, *A. dasystachyum*, *A. Smithi*; *Sporobolus brevifolius*.

⁵ *Liatris punctata*; *Solidago missouriensis*, *S. mollis*, *S. rigida*, *S. serotina*; *Ratibida columnaris*; *Chrysopsis mollis*, *C. hirsutissima*; *Aster hebecadus*, *A. oblongifolius*; *Grindelia squarrosa*; *Brauneria angustifolia*; *Ambrosia trifida*; *Artemisia frigida*, *A. aromatica*; *Helianthus Maximilianus*; *Achillea millefolium*; *Lycodesmia juncea*; *Erigeron asper*, *E. pumilus*, *E. ramosus*; *Sideranthus spinulosa*; *Actinella simplex*.

⁶ *Petalostemon purpureus*, *P. oligophyllus*; *Amorpha canescens*; *Lotus americana*; *Astragalus caespitosus*, *A. succulentus*, *A. canadensis*; *Aragallus Lambertii*; *Lupinus argentus*; *Psoralea argophylla*, *P. cuspidata*, *P. digitata*, *P. tenuiflora*.

⁷ *Allium reticulatum* and *A. rubrum*; *Leucocrinum montanum* and *Fritillaria atropurpurea*.

⁸ *Capsella bursa-pastoris*; *Erysimum asperum*, *E. inconspicuum*; *Lesquerella lunellii*, *L. argentia*; *Sophia incisa*, *S. pinnata*; *Arabis hirsuta*.

evening primroses⁹ are conspicuous because of showy flowers. Chenopods¹⁰ are plentiful in the more clayey or more sandy areas. Three genera of scrophs or beard's tongues¹¹ help adorn the plains. The roses, wild flax, milkwort, false mallow, puccoon, plantain, *Oreocarya*, and *Cogswellia* also are represented abundantly.¹²

BIRDS¹³

Among birds the only permanent resident represented by many individuals is the desert horned lark.¹⁴ Longspurs of some species are found in all seasons, the chestnut-collared and McCown's longspurs nesting here abundantly and the Lapland longspur wintering here. Two other members of the sparrow family, the lark bunting and the western vesper sparrow, are very numerous. The former is quite characteristic as is also the desert horned lark. Other prominent nesting birds are the Brewer's blackbird, burrowing owl, Sennett's nighthawk, upland plover, marsh and Swainson's hawks. Formerly the long-billed curlew and the prairie sharp-tailed grouse were common. Several birds nest in the groves or scattered trees along the streams (considered here as woodland), but often feed upon the steppe far from their nests. Examples are the ferruginous, rough-legged, and sparrow hawks. The cliff and barn swallows, nesting on cliffs or about buildings, also are seen often.

MAMMALS

No conspicuous species appears to be confined in its range to the steppe of the Northern Great Plains, though several varieties are. Of these the plains coyote, plains pocket-gopher, certain mice and voles may be mentioned.¹⁵ Other mammals abundantly represented on the steppe are the¹⁶

⁹ *Anagra albicaulis*, *A. Nuttallii*; *Onagra striogosa*; *Gaura coccinea*; *Meridolix serrulata*.

¹⁰ *Chenopodium album*, *C. Fremontii*, *C. uncanum*, *C. Watsonii*, *C. pratinoeca*, *C. dacoticum*; *Atriplex argentea*, *A. canescens*, *A. Nuttallii*, *A. Suchleyana*; *Suaeda erecta*.

¹¹ *Castilleja flava*; *Orthocarpus luteus*; *Pentstemon acuminatus*, *P. albidus*, *P. erianthera*, *P. grandiflorus*.

¹² *Rosa arkanseana*, *R. Fendleri*, *R. Woodsi*; *Linum Lewisii*, *L. rigidum*; *Polygala alba*; *Malvastrum coccineum*; *Lithospermum angustifolium*, *L. linearifolium*; *Onosmodium occidentale*; *Plantago elongata*, *P. Purshii*; *Oreocarya glomerata*, *O. perennans*; *Cogswellia macrocarpa*, *C. montana*.

¹³ For somewhat detailed discussions of the birds of the steppe of South Dakota, see the sections on birds in the reports by the writer mentioned in footnote 3, and articles by him in *The Auk* for 1909, 1911-13, and the *Wilson Bulletin* for 1912, 1913, 1915.

¹⁴ In the interest of brevity and simplicity, technical names are used here only in case the common name does not indicate the plant or animal under discussion with a definiteness sufficient for the purpose of this article. Since the American Ornithologists' Union adopted distinctive names for the American birds at an early date and since these names are now familiar to all students of birds, the common names may be used here without misunderstanding. The scientific names of various widely distributed and well-known animals, such as the pronghorn antelope, bison, gray wolf, striped gopher, common toad, and rattlesnake are given only once or twice. As most common names of plants apply to more than one species, technical names usually are necessary for precision, and therefore are used more frequently. Reference to a plant by its incomplete name implies that the species is the one enumerated in the list of conspicuous species, where technical names will be found, or the one mentioned only a few lines above.

¹⁵ *Canis latrans*; *Thomomys clusius*; *Geomys (bursarius) lutescens*; *Peromyscus maniculatus nebrascensis*, *P. leucopus aridulus*; *Perognathus fasciatus*.

¹⁶ *Cynomys ludovicianus*; *Taxidea t. latas*; *Lepus c. campestris*; *L. californicus montanois*; *Mephitis (Chincha) hudsonica*; *Spilogale interrupta*; *Canis nubilus*; *Vulpes velox*; *Muscula longicauda*; *Citellus tridecemlineatus olivaceus*, *C. t. tridecemlineatus*; *Antilocapra americana*; *Bison bison*.

prairie-dog, badger, jackrabbit, large and small skunks, gray wolf, kit-fox or swift, long-tailed weasel, thirteen-striped spermophile, and formerly the antelope and bison (Fig. 4).

OTHER ANIMALS

The most common snake is the plains bull snake, with the plains blue racer next, and the western prairie rattlesnake third in most places and seasons. The horned lizard is numerous in many localities. The common toad is seen frequently. The Great Plains toad is characteristic but not abundant.¹⁷

Invertebrates, aside from the insects, are unimportant in this group of associations. It appears that only three of the numerous phyla are represented, the protozoa relatively sparsely, mollusca chiefly by but one species of land snail (*Succinea grosvenorii*), and the arthropoda by a few spiders¹⁸ and centipeds, and by numerous insects of six of the eight orders: Orthoptera (grasshoppers and locusts), Diptera (gnats, mosquitoes, flies), Lepidoptera (butterflies and moths), Coleoptera (beetles) and Hymenoptera (bees, wasps, ants, and ichneumons), and Hemiptera (bugs). The locust and grasshoppers¹⁹ are the most conspicuous insects and most injurious.

The Hymenoptera of several families (digger wasps, ants, woolly bees) are abundant. Blow flies, bot flies (*Gastrophilus equi*), and robber flies are plentiful. Lepidoptera are few upon the steppe.²⁰ The beetles are mostly ground beetles.²¹ Bugs are very rare on the steppe.

"ADAPTATIONS" OF THE LIFE OF THE STEPPE TO GEOGRAPHIC CONDITIONS

PLANTS

The plants display a variety of characteristics seemingly related to the environment, including:

The predominance of perennial grasses and herbs, the latter belonging chiefly to the higher orders. Although in favorable years annuals are conspicuous, herbaceous perennials are the characteristic vegetation. There are no large shrubs, and no trees. This characteristic is in contrast to woodland, desert, prairie, tundra, and most marshes.

The relatively firm turf which prevails in the more favorable portions of the steppe hinders the establishment of annuals, which are much more conspicuous therefore in the more arid and more sandy portions. Prairie fires occur frequently where there is a fairly close turf, for reasons already mentioned. Fires are powerful factors in preventing the spread of trees

¹⁷ The technical names of these reptiles are: *Ptygophis catenifer sayi*; *Bascanion constrictor flaviventris*; *Crotalus confluentus*; and *Phrynosoma douglasi hermandesi*; of the toads: *Bufo americanus* and *B. cognatus*.

¹⁸ Mostly of the jumping (*Phidippus*) and running types.

¹⁹ The genera more abundantly represented include *Melanophus* (*M. brevittatus* and others); *Sparogemon* (*S. aequalis* and others); *Dactylopsoma* (*D. pictum*); *Philibotoma*; *Hippicus*; *Dissostera* (*D. Carolina*); *Brachystola* (*B. magna*); *Nachyrhachis*; *Xiphidium*; *Opeia*; *Oecanthus*; *Hadrotettix* (*H. trifasciatus*).

²⁰ Perhaps the following include the more abundantly represented genera: *Arymnus*; *Apatelia*; *Basilarchia*; *Chrysophanus*; *Cochymympha*; *Colias*; *Lycena*; *Thanaos*.

²¹ *Elctodes obsoleta*, *E. opaca*, *E. tricolorata*; *Silpha ramosa*; *Harpalus eraticus* and others.

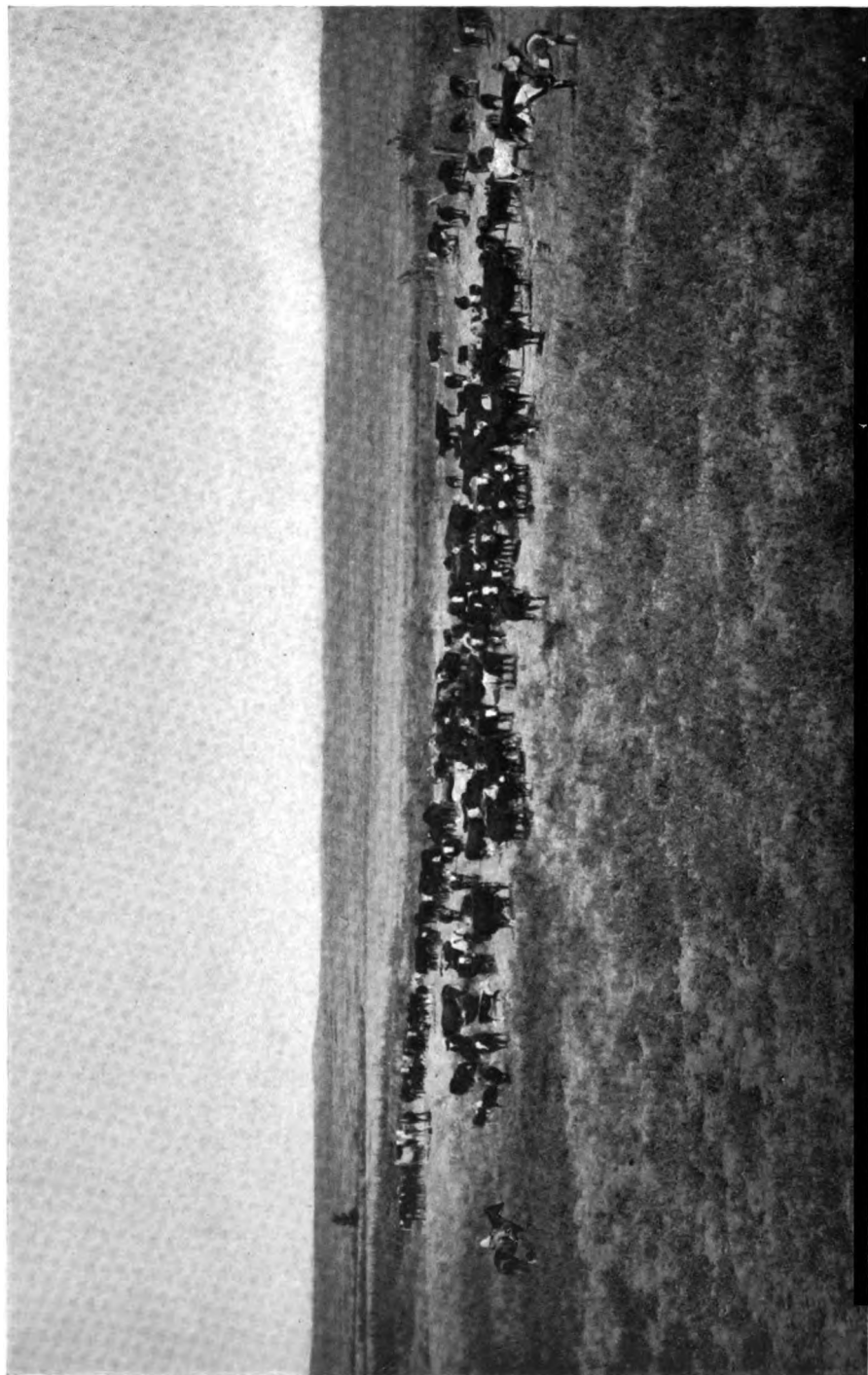


FIG. 2—A view on a cattle ranch near the southwestern corner of South Dakota. The coarse herb in the foreground is the "wild alfalfa," *Pseudotsuga*.

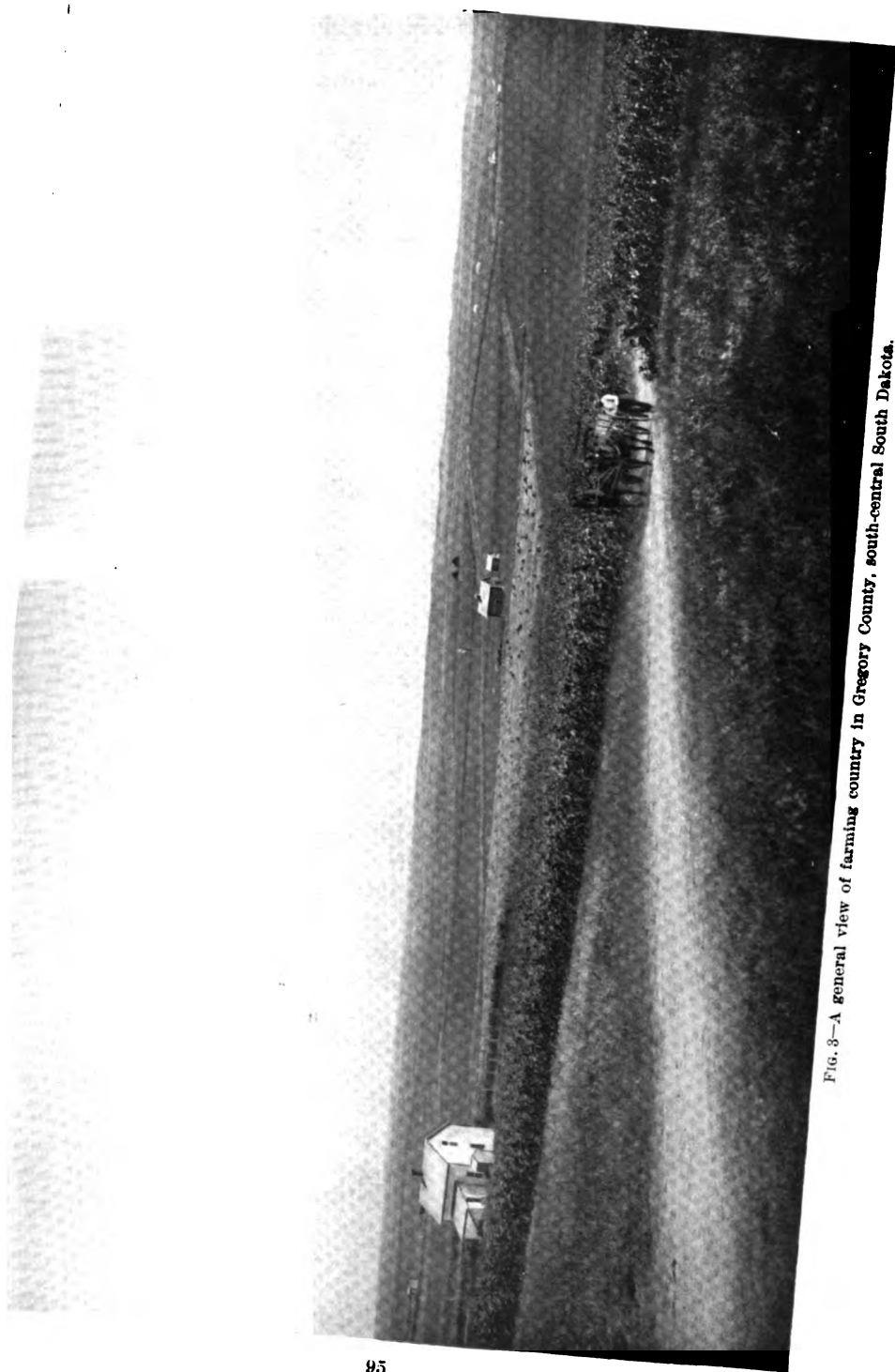


FIG. 3—A general view of farming country in Gregory County, south-central South Dakota.

and shrubs. The larger shrubs are restricted chiefly to the more arid or more rugged portions where vegetation is discontinuous in its distribution and where combustible material is separated rather widely. During the six or eight months in which there is little vegetative activity because of the lack of sufficient heat or moisture, evaporation from all exposed living surfaces is continued by the drying winds which prevail on the steppe. Plants not presenting living surfaces from which extensive evaporation takes place when the water lost cannot soon be replaced, have an advantage over other species. If planted on the steppe, most of the shrubs and trees not especially resistant to loss of moisture through the bark, are killed during the months of inactivity rather than during the normal summer season.

Compactness of stalk or flowers, or both. Compactness of stalk is illustrated by almost all the plants. Few abundant upland species reach a height, in ordinary seasons, of much more than a foot, and exceedingly few reach three feet. The majority have most of their bulk within six inches of the soil (Figs. 2 and 4). The rose, sunflower, sage, and golden-rod, which have representatives in other ecological formations, are in most cases represented on the steppe by the dwarfed species of the genus. Two striking examples of small size are the plains rose, in many cases a simple bush less than five inches tall which bears but one flower, and the plains sunflower, which in most cases is less than seven inches high and in dry years, especially on clay, has many individuals which are less than four inches high. The conspicuous places held in the flora by the Compositae points to compactness of flowering parts. Even the grasses (grama, buffalo, wheat, and others) have the spikelets somewhat compactly arranged instead of loosely as in typically prairie and woodland species. Compactness of growth decreases exposure to the winds. In most ecological formations an insufficiency of sunlight results in a diffuse and extended growth. There is no such insufficiency during the growing season in the steppe.

Specialization of the root system. There are many plants which have developed a shallow, wide-spreading root-system. This appears to be a response to the many slight showers, the water of which does not soak in deeply. The buffalo and grama grasses have roots which penetrate a foot from the surface. In contrast to these there are such deep-rooted plants as *Psoralea*, a rather coarse herb, which has almost all of its finer roots at a depth greater than four feet, and in some cases penetrates hard subsoil more than six feet, and looser materials still farther. Certain genera, including the sages (*Artemisia*) and *Gutierrezia*, have both well-developed lateral roots and rather deep tap-roots. Most plants which are abundant on the more impervious soils have shallower root systems than those in the looser soils. Shrubs and coarse herbs have root systems which go down to greater depths than do those of lesser plants, probably because of their greater exposure to the winds. They need firmer anchorage and a more reliable water supply than is found near the surface. The plants showing storage

of water in enlargements of the roots are chiefly the blazing-star, the Indian-turnip (*Psoralea esculenta*), and the bush morning-glory (*Ipomoea leptophylla*). The cacti (*Opuntia*, *Mamillaria*) are the only plants which store considerable amounts of water above ground.

Prevalence of narrow or small leaves or thick cutin (epidermis). Most of the plants have either short or narrow leaves or both, and a few, like the prairie-pink, *Gutierrezia*, and the cacti, are almost leafless. Abundant species with resin include the cone-flower, gum-weed, and *Psoralea*.²²

Many species have a thick epidermis, which in many cases is covered by numerous dry scales. The sages (*Artemisia*, *Eurotia lanata*), *Psoraleas*, and *Antennarias* have a grayish coloration due to such scales (Fig. 2).

These characteristics of leaves and cover clearly retard evaporation and thus appear to be responses to the moisture conditions of the steppe.

Pollination and seed dispersal accomplished, in a vast majority of the species, by the wind. The seeds of nearly 90 per cent of the abundant species on the steppe are distributed by the wind. The tumble-weed habit, in which the aerial part of the plant becomes detached from the root and is rolled across the plains by the wind, is developed almost solely by plants of the wind-swept plains. Several species with this habit, belonging to several families, are represented abundantly in the Northern Great Plains. The chenopod family is the chief one and is represented by the giant tumbleweed, the Russian thistle, and the bug-weed. Two legumes, the Indian-turnip and the wild alfalfa, two species of the *Amaranthaceae*, a composite, and two grasses also have this habit.²³

Persistent surface winds, few places of lodgment such as (1) bodies of water, (2) very rugged areas, (3) thickets and other places unfavorable for steppe plants, and the scarcity of other agents of dispersal, all have contributed to the predominance of species dispersed by the wind.

Ability to mature quickly. The ability to mature quickly is possessed by most plants in this formation. The period between killing frosts in spring and fall is short, averaging about 120 days and having a minimum length of more than a month less. The growing season is shortened usually still further by dry weather in August and September. Few conspicuous plants require more than two months for the maturing of their seeds, and many need even less time. This is in contrast to the condition in most other formations.

Time of growth not closely confined as to season. The climate of the steppe is variable. In some years the vegetation is two weeks ahead of normal, and the next year it may be far behind. Delayed rains may cause a surprisingly late flowering. We have found the rose and even the pasque flower late in August, following July and August rains and a very dry spring and early summer.

²² Especially the case in *P. digitata*, *P. linearifolia* and *P. tenuifolia*.

²³ The chenopods are *Cyclonia artiplicifolium*, *Salvia pestifer*, and *Corispermum hyssopifolium*; the legumes, *Psoralea esculenta* and *P. floribunda*; the amaranths, *Amaranthus albus* and *A. graecisans*; the composite, *Townsendia sericea*; the grasses, *Panicum capillare* and *Schedonnardus paniculatus*.



FIG. 4.



FIG. 5.

FIG. 4—A view in the buffalo-grama grass association near Pierre, S. D. The velvet-like smoothness of the vegetation is suggested. The bison, a protected and much-prized herd, recall the enormous herds formerly found in this region.

FIG. 5—The prickly-pear is one of the most conspicuous plants of many areas in the Northern Great Plains. The grass in flower is the grama grass, far more useful and gentle than the cactus. The warping noticeable in several sections of the cactus indicates a depletion of their water content. Shortly after rains they often are distended.



FIG. 6.



FIG. 7.

FIG. 6—The spurge "snow-on-the-mountain" is perhaps the most conspicuous annual of the southern half of the area under consideration.

FIG. 7—A view in the bunch-grass association of south-central South Dakota. The trees, on a cliff, are Rocky Mountain yellow pine. The near clumps of vegetation are bunch grass and yucca (Spanish bayonet), the latter in fruit.

Destruction of exposed parts usually does not result in the death of the plant. The characteristic steppe plants have a wonderful resistance to prairie-fires and grazing, which may frequently destroy the aërial parts. Many typical plants, such as trees and shrubs, of other ecological associations are killed by the destruction of only a small part of the aërial growth. Certain steppe species are killed, however, by too frequent fires (oftener than once in three years, for example) or by close pasturing.

Ability to withstand inactivity, forced by drought, for even two or three years. After a series of wet years there are many new immigrants into the steppe. A dry year or two decimates or eliminates species which are only visitants to the steppe. The characteristic species seem to be almost uninjured by even prolonged drought. In the summer of 1911, for example, there were localities which for two years had been so dry that almost no grass had grown; yet when the unusual rains of August came, the ground was green within a few days.

Resistance to unseasonable warm spells and frost. The vegetation does not start quickly in the spring; but if, after it has started, a freeze comes, surprisingly few of the more characteristic plants are killed. The native steppe vegetation is seldom affected noticeably by early autumn frosts. In areas less likely to have unseasonable frosts, many species are severely injured when such frosts occur.

Marked seasonal succession depending on accumulated heat, water content of the soil, relative humidity, and precipitation. The succession of flowers, in an ordinary year, is striking. There are at least five well-marked periods, the prevernal, vernal, aestival, serotinal, and autumnal. During one period the plains are dominated by one group of flowers and during the succeeding periods by still others. The early bloomers of the steppe include *Cymopterus accaulis*, pasque flower, violet (*Viola Nuttallii*), and prairie lily. Among those blooming in June are the beard's tongue,²⁴ onions, camas (*Zygodenus intermedius*), loco, buffalo bean (*Astragalus*),²⁵ wild flax.²⁶ In July, niggerhead (*Braunia*), prairie-clover, wild alfalfa (*Psoralea*),²⁷ false mallow, stemless evening primrose (*Gaura*), and spurge are prominent. During August, the numerous species of asters,²⁸ golden-rod,²⁹ and the flea-bane (*Senecio canus*) are in their glory. The sages³⁰ are in full bloom early in September.

Accompanying this progressive activity there occur transformations in the floristic complexion of the region. *Early in the season the plants are related mainly to eastern or mountain species, while, as the season advances,*

²⁴ *Pentstemon acuminatus*, *P. albidus*, *P. cernanthera*, *P. grandiflorus*.

²⁵ *Astragalus caryocarpus*, *A. flexuosus*, *A. lotiflorus*, *A. microlobus*, *A. missouriensis*, and *A. triphyllus*, in addition to those given in footnote 6.

²⁶ *Linum Lewisii*, *L. rigidum*.

²⁷ Mentioned in footnote 6. The next three plants are *Malvastrum coccineum*; *Gaura coccinea*; *Euphorbia marginata*, *E. arkanseana*.

²⁸ *Aster commutatus*, *A. hebecladus*, *A. multiflorus*, *A. oblongifolius*.

²⁹ *Solidago memorialis*, in addition to those mentioned in footnote 5.

³⁰ *Artemisia aromatica*, *A. cana*, *A. frigida*, *A. ludoviciana*.

conditions become more severe and the active or dominant species are successively related to plants of the prairies, drier plains, and finally the desert.'

This succession corresponds with changes in the temperature of air and soil and in the moisture-content of soil and atmosphere.

Predominance of yellow flowers. Many of the more abundant species are yellow, although several conspicuous flowers are white, orange, or pale blue. There are few reds, deep blues, or violets. Very few are streaked or mottled. In the vast majority of cases the flowers are small in size as compared with those of other plant formations, and few are particularly fragrant. The color probably is related to the light conditions, and the fragrance to the windiness, which also affects the size of flower.

BIRDS

The birds of the steppe possess two or more of the following characteristics:

Nests are necessarily built on the ground.

Many kinds sing while on the wing. Examples are the lark bunting, longspur, Sprague's pipit, and frequently the western meadow-lark and horned lark.

The songs and calls are louder than those of birds of woodland or prairie. Because of the climatic conditions of the steppe, representatives of species in many cases are farther apart than in most other areas. Calls and songs fulfill their chief purpose only when they are heard by other individuals of the species, and therefore need to be relatively loud in the steppe.

*Social flocking*³¹ *is less prominent than among the birds of the woods, water, or prairies,* where not only do various species migrate in large flocks, but troops wander socially about in other seasons, especially in winter, and several abundant species nest in colonies. The grackle, crow, swift, swallows, night-herons, blackbirds, marsh wrens, numerous water-birds, and the bobolink and dickcissel are examples. If the cliff swallow, which nests here and there in the badlands, be excepted, none of the abundant birds of the steppe nest in colonies. The scattered distribution of life on the steppe, noted in the preceding paragraph, is exemplified in the distribution of the nests of the steppe birds. The lark bunting and longspurs, and occasionally the Swainson's hawk, migrate in flocks which soon break up, however. Flocking in the winter is largely accidental. Birds gather where food is available, in areas swept by the wind or in patches of taller vegetation which are not snow-covered. Weedy fields, where seeds are abundant, are the favorite sites of such gatherings.

Many have the ability to withstand strong wind. For example, seed-eaters feed during the winter in apparent comfort on wind-swept hills.

³¹ Statements made by Wallace Craig in the paper referred to in footnote 1 have led to the erroneous generalization by a few animal ecologists unfamiliar with birds that gregariousness is a characteristic of steppe birds.

Females and nestlings are almost all protectively colored. This seems required by the exposure of the nesting sites.

Most species are highly migratory. Few individuals remain during winter, and these are of species different from those of summer, except in the case of the desert horned lark. Even this species migrates in a limited sense. The aridity and the inactivity of other life combine with the cold to encourage the desertion of the steppe during the winter season.

Most birds have the ability to withstand the intense heat of the sun. This is especially notable in the nestlings, which are often on dark ground.

The birds of the steppe of necessity must require but little drinking water. Heavy dews are rare.

The power of acute long-range vision appears to be possessed by a much larger number of the birds of the steppe than by those inhabiting woodlands. Clearness of atmosphere, moderate relief over large areas, and the widely scattered distribution of life all probably have encouraged the development of acute long-range vision.

MAMMALS

The mammals of the steppe have all acquired two or more of the following characteristics:

Ability to run swiftly. Examples are the antelope (32 miles an hour), jackrabbit (28 miles per hour), coyote (24 miles an hour), kit-fox, or swift (20 miles an hour), and gray wolf (20 miles an hour).³²

It is possible to run more swiftly upon dry grassy plains than through woods or brush, in marshes or across rugged tracts. For this reason the inhabitants of such plains have come to be the fleetest of runners. Long-distance running was developed among some of the larger mammals, apparently because of the relative scarcity of places of retreat.

Ability to burrow. Examples are the pocket-gophers, striped gophers, badgers, prairie-dogs, mice voles. About 70 per cent of the species rear their young in burrows and nearly 50 per cent of the species spend much of their time underground. Burrows are retreats from heat, cold, wind, and some enemies, and for the prairie-dog, at least in some cases, furnish access to the underground water supply.

Many have acute long-range vision. The fleet runners all have. This appears to have been developed by the same factors mentioned in the discussion of the vision of birds.

A gray or tawny type of coloration which harmonizes well with dead leaves is possessed by nearly all. The skunk, an exception, is less in need of protective coloration than are the other mammals of the plains.

Ability to do without much drinking water. Water for physiological activity and for cooling by perspiration is secured mainly from the food

³² Velocities are those attained by the normal, healthy adult when pursued by greyhounds, and are quoted from Ernest Thompson Seton: *Life Histories of Northern Animals*, 2 vols. (New York, 1909).

eaten. Footprints of most steppe mammals are seldom seen in mud about water holes. This is especially true in regard to the rodents, including the jackrabbit.

The daily period of activity is chiefly in the early morning, in the evening, and to a lesser degree at night. Voluntary activity of almost all abundant mammals of the steppe is very limited during the heat of the summer day, when as many as may are in the shade. Activity generates heat, which must be eliminated by perspiration, which in turn requires water, an article which is precious.

Ability to hibernate. The long-distance runners and the carnivores do not hibernate, but, with the exception of the rabbits, rodents, the most numerous mammals on the plains, do, and for longer periods than related species in other formations. Hibernation is a response to the unfavorable conditions which prevail during the winter months.

The larger herbivores, bison and antelope, migrated chiefly in response to irregularity in precipitation of rain and snow. Wolves, which preyed upon them, accompanied them in their wanderings.

A few of the mammals of the steppe are gregarious; the bison and antelope congregated probably for protection from wolves and bears and in response to the lack of numerous places of escape; but also in winter for the heat accumulated in a closely packed herd. Prairie-dogs are grouped into towns for protection against coyotes and certain hawks, and possibly by the somewhat restricted soil and ground-water conditions which they appear to require.

REPTILES

The reptiles, chief among which are the bull-snake, rattlesnake, and blue-racer, and the horned lizard, possess a surprisingly effective coloration; hibernate for nearly half the year, or even longer; can get along without drinking water; and are of small size as compared with related forms in more humid areas. Although the vast majority of reptiles lay eggs, two of the five abundant steppe reptiles (the rattler and horned lizard) bring forth their young alive. This may be in response to the "hard" climatic conditions which confront the young at birth.

INSECTS

Concerning the insects of the steppe, the following points may be made.

The diurnal period of greatest activity is in the forenoon from seven to eleven o'clock, after the chill of the early morning is gone, but before the heat becomes oppressive. Coitus is indulged in chiefly between eleven o'clock and one. During the rest of the twenty-four hours most of the insects are quiescent except when disturbed.

Seasonal activity is limited practically to the warmer and more moist three or four months of the year, chiefly June, July, and August. There is

almost complete inactivity during the colder and drier months of the year. Most species are dormant during ten or eleven months of the year, when many are represented chiefly by eggs.

Many forms burrow or occupy the burrows of mammals, in so doing having retreats from wind, heat, cold, and some enemies. Steppe species in many cases burrow to much greater depth than related species of other communities.

There is a predominance of hoppers or fast walkers. The development of hopping as a chief mode of progression is not so much discouraged on the steppe as in several other formations by frequent collisions with tall vegetation. The habit of running is favored by bare soil and is more marked among the insects of the drier than of the moister parts of the steppe, and still more among those of the desert.

Few species spend much time on the wing. The windiness of the steppe discourages extended flights. The occasional large flights of locusts form conspicuous exceptions to this rule.

REMARKS CONCERNING THE SEVERAL ASSOCIATIONS COMPRISING THE STEPPE

THE BUFFALO-GRAMA GRASS, OR CLIMAX STEPPE, ASSOCIATION

This is the short-grass association par excellence and in many respects is the most characteristic steppe association (Fig. 4). In the central part of the steppe region it is found on a variety of medium soils, lighter clays, silts and loams, and is the dominant association over wide stretches. As the heavier and lighter soils are altered to loams by mixture and other processes, and as the drainage is perfected and ruggedness decreased, this association is extended at the expense of the other steppe associations.

To the east of the Great Plains province, the buffalo-grama grass association is represented on the high prairies on well-drained clay soil. In the more arid belt to the west it is found where the run-off is less rapid, as on the flattish tops of buttes and on terraces.

One of the two dominant grasses, the short, curly, buffalo grass is less tolerant of sand than is the taller grama grass, various species of which are of secondary importance in distinctly sandy areas.

The life of this association is more varied than that of other parts of the steppe. Many of the species mentioned as represented generally in the steppe are most abundant here, and in no other part of the steppe is found so large a number of species. In addition, the wire grass is abundant upon the more silty and loamy areas, and the needle grass (*Stipa*), and prairie June grass (*Koeleria cristata*) on the more sandy soil. The small milk-weed (*Asclepias pumila*), the pincushion cactus (*Mamillaria vivipara*), and *Parosela aurea* are rather numerous.

Nearly all the birds of the steppe nest usually or occasionally in this association. Sprague's pipit is here characteristic. The bison and the prong-

horned antelope appear to have been at home here. The striped gopher is most abundant here, but reptiles and toads are less abundant.

THE NEEDLE GRASS, OR SANDY-LOAM STEPPE, ASSOCIATION

This association occupies uplands on sandy-loam soil and is characterized by the needle, devil's or spear grass, and June grass, just mentioned. In areas of rather uniform soil and topographic conditions these two grasses may dominate. In more sandy areas, coarse herbs of *Astragalus*,³³ lupines, and *Psoraleas* are very conspicuous and comparatively uniformly distributed, and sand grass occupies small areas, especially on slopes. In soils having a larger percentage of silt or clay, there are patches of buffalo and grama grass. The lead-plant is in evidence in areas of coarse sand or gravel mixed with finer materials. These herbs, and others that are represented less abundantly, have showy blue flowers. During the weeks preceding the shedding of the needles, this association is perhaps the most beautiful among all those of the steppe, because of the needles which glisten and wave in the breeze and the blue flowers then conspicuous. These are set off by the yellow and brownish flowers so widespread on the steppe. When the needles are ripe they become readily attached to clothing, long hair or wool, and by the help of several twists which develop as the needles dry, readily work inward and often cause pain. For obvious reasons, hay containing many needles is much less desirable than common prairie hay. The mowing and grazing, especially by sheep, of areas infested with needle grass is confined preferably to the season before the seeds begin to ripen early in July.

THE WHEAT GRASS, OR CLAY STEPPE, ASSOCIATION

The dominant grass on clay is the western wheat grass, sometimes popularly known as salt grass. It is widespread in areas where shales outcrop and along flood-plains. This grass has a very much larger percentage of its growth more than two inches from the soil than do the other widespread steppe grasses of fairly level areas. It also responds to an increased supply of water in a more satisfactory manner than the other abundant steppe grasses; in fact in some places and in some seasons, it attains a height of two feet. It therefore is a valuable hay crop along the flood-plains and on other areas which are flooded frequently, but upon which the water does not stand long. Because clay is relatively impervious, the percentage of absorption is slight except where the water stands for a time. In response to these geographic factors, enterprising farmers and stockmen erect wing dams and dig contour ditches in favorable places, and use flood waters to produce excellent meadows.

Although wheat grass is present in a rather pure stand in areas which are flooded frequently, in many places various other species are conspicuous.

³³ *Astragalus mollissimus*, *A. adsurgens*, *A. canadensis*; *Lupinus pusillus*.

The variety of abundant plant and animal life is normally less in this than in other parts of the steppe, however.

On well-drained slopes on the "gumbo," the vegetation is scanty except in wet seasons, and the soil is little concealed. Among the scattered growth of grass, various chenopods³⁴ and the crucifer pepper-grass (*Lepidium*) and prickly-pear cactus and the dock (*Rumex venosus*) are conspicuous in many places, as are also the Dakota vetch and the gumweed.

On the somewhat alkaline soil of many "blow-outs" and other undrained depressions, alkali grass replaces wheat grass, while the smaller prickly-pear (Fig. 5) is in many places exceedingly abundant. Two or three kinds of chenopods are often conspicuous.³⁵

On valley flats the spurge, "snow-on-the-mountain" (*Euphorbia marginata*, *E. Arkansana*), is dominant in some seasons in many places, especially near the bluffs and in prairie-dog towns. It is perhaps the most conspicuous annual growing on the steppe (Fig. 6). The bur-tomato (*Solanum rostratum*) is another annual which is sometimes conspicuous in similar situations and also in deserted fields. Since valley flats receive the run-off from an extensive area, there is a sporadic occurrence of numerous species belonging to other associations, many of which, however, do not mature their seeds.

The wheat-grass association is at many points contiguous to groves along the streams and to shrubby associations, especially the buck bush and sage, and upon the areas of alluvium, with buffalo-grama or meadow-grass associations.

Few birds nest in the wheat-grass association. The relative barrenness of the upland areas and the frequency of flooding of the other portions are doubtless major deterrent influences. The sharp-tailed grouse, however, is more numerous in the flood-plain phase of this association than elsewhere, possibly because the taller vegetation affords more protection than the upland associations. Each prairie-dog town has one or more broods of burrowing owls.

The prairie-dog is the most conspicuous mammal. In parts of this association, notably in southwestern South Dakota, nearly every low terrace along the valleys is occupied along much of its extent by prairie-dog towns. The danger of being drowned out by the flood water is greatly decreased by piling up around each hole much of the dirt brought up from below. Many entrances are as much as 12 or 15 inches above the general level of the "flat." This piling up is not accidental, as is shown by the repeated repairing by scraping dirt in from the periphery of the mound, and by the fact that in areas not subject to frequent flooding the detritus brought up from

³⁴ *Atriplex canescens*, *A. hastata*, *A. Nuttallii*, *A. phelonitica*; *Chenopodium album*, *C. Fremontii*, *C. glaucum*, *C. dactyloides*, *C. subglabrum*, *C. pratensis*, *C. Watsonii*; *Corispermum nitidum*; *Monolepis nuttalliana*; *Suaeda erecta*, *S. depressa*.

³⁵ This grass is *Distichlis spicata*; the cactus *Opuntia fragilis*; the most numerous chenopods, *Atriplex canescens* and *Monolepis nuttalliana*. The purslane *Talinum parviflorum* sometimes is conspicuous and nearly always is characteristic of blow-outs.

below is scattered widely. The long-tailed weasel and the black-footed ferret, which prey upon the prairie-dog, are numerous, though not often seen. Gophers and other burrowing mammals are lacking in most of the flood-plain areas in the gumbo region, probably because of the floods.

THE BUNCH-GRASS, OR DRY-SOIL STEPPE, ASSOCIATION

The dominant feature of this association is the bunch grass, which attains a rather uniform height of about 15 inches. The clumps are stiff, sparingly eaten, and conspicuous throughout the year since they are seldom covered by snow for more than a short time.

This association has two distinct phases, (1) on slopes in rugged areas, bluffs along streams and in moraines, where the soil is not clay or sand; (2) on relatively pure sand. The latter may be subdivided into (a) the more nearly level stretches and (b) the sandhills. The first phase (Fig. 7) occupies but a small total area, but is widespread, being present in each of the districts and in most of the sub-districts of the Northern Great Plains. The second phase is best developed in middle and western Nebraska, where sand, commonly heaped into dunes, is dominant. The area of dunes reaches a very short distance into south-central South Dakota. This association also is present in some places along valleys where the alluvium is very sandy.

The determining geographic factors in this association appear to be a scarcity of moisture in the surface layers of the soil, and a soil which is readily penetrated by roots. In areas of sand, although the run-off is slight, there is normally but little moisture in the upper six inches or more. This is the result of the active evaporation which persists until the capillary tubes are broken. Consequently vegetation possessing only shallow root systems, as does much of that of the buffalo-grama and wheat-grass associations, is barred. The vegetation of this association is characterized by deeply penetrating root systems, in many cases with prominent "tap-roots."

The Spanish bayonet, or soap-weed (Fig. 7), is conspicuous, while *Mentzelia* and the pasque flower are numerous on the steeper slopes outside the sandhills.³⁶

The bird most generally nesting in this association is the western vesper sparrow. The western field sparrow is locally numerous. Several mammals, notably the jackrabbit, coyote, and badger, often rear their young in the rugged areas dominated by bunch-grass. Such areas afford partial protection by their tall vegetation as well as by their relief. The rapid run-off is an additional factor in their desirability as bird resorts.

The sandhills³⁷ as seen from a distance are not inviting; they appear as a low line of monotonous yellowish hills, or, if one look down from a divide, a complex of irregularly arranged dunes with here and there the glimmer

³⁶ *Yucca glauca*; *Mentzelia nuda* and *M. decapetala*; *Palafoxia hirsutissima*.

³⁷ R. J. Pool's study of the vegetation of the Nebraska sandhills (see footnote 3) is a voluminous report. For a brief earlier account, see S. S. Visser: The Plants of the South Dakota Sandhills, *American Botanist*, 1914.

of a pond. Only the bright yellow of a patch of freshly exposed sand, or the dark green of a marsh filled with vegetation, break the monotony.

It is only when one is within the dune district and sees the variety of vegetation that the reason for the reputation which sandhill districts have among botanists and picnickers becomes evident. There is a striking contrast between the more level, dry clay plains covered with a carpet of short "buffalo" grass and the rough sandhills, with their tall clumps of bunch grass, many fruiting shrubs, and narrow valleys filled with dense thickets through which ripple clear, cold brooks. Though the sand is fairly fertile, it is likely to drift badly when cultivated. Pastures here are in ill repute, because of the tendency of their soil to blow; and although there are small meadows, the roads are so heavy that it does not pay to haul hay far. Perhaps it is the impression of irredeemable wildness that gives the sandhills part of their attractiveness.

The many differences between the adjacent grassy plains and the sandhills seem to be due almost entirely to the sand. In elevation there is no notable difference; it is not likely that there is more precipitation; it is readily apparent that the sandhills in general are no cooler.

The sand, being loose and porous, absorbs at once all rainfall, even during a heavy shower. The result is that before any considerable percentage of a given rainfall has disappeared by evaporation it is beyond reach of the chief agents of evaporation. The balance escapes slowly from the many voluminous springs which supply the brooks and from the leaves of the vegetation.

As might be expected, the air temperatures become very high during sunny days, especially in the depressions. The vegetation must either be able to endure rapid evaporation or it must be able to resist drying by possessing restrictions against evaporation. Both responses are found. The bunch grass (*Andropogon*), roses, bush morning-glory, sunflower, and sand thistle are examples of the former; the cacti, sand cherry, yucca, and prairie-pink are conspicuous examples of the latter. A number of the characteristic plants have much longer tap roots than even closely related species of the areas of harder subsoil; a few, including the cacti, bush morning-glory, and *Psoralea lanceolata* have organs for storage of water.

The prominent plants are perhaps the following.³⁸ The bunch grass is dominant; sand grass, and spear or needle grass are common, both growing here in small clumps. Grasses growing between the bunch-grasses are hair grass, grama grass, and the sand-bur. The shrubs of the sandhills are sand-cherry, choke-cherry, plum, dogwood, prairie willow, lead plant, buffalo-berry, and the wild rose. Spanish bayonet is abundant.

³⁸ The technical names of these prominent plants are: *Andropogon scoparius*, *Calamovilfa longifolia*, *Stipa comata*, *Eragrostis trichoides*, *Bouteloua hirsuta*, *Cenchrus tribuloides*, *Prunus Besseyi*, *P. melanocarpa*, *P. americana*, *Cornus stolonifera*, *Salix humilis*, *Amorpha canescens*, *Lepargyrea argentea*, *Rosa woodsii*, *R. arkansana*, *R. suffulta*, *Yucca glauca*.



FIG. 8.



FIG. 9.

FIG. 8—Looking southeastward from Sheep Mountain, S. D.: one of many splendid views in the White River badlands. The steep slopes are nearly bare. At the right a gnarled cedar and some greasewood plants may be seen.

FIG. 9—This view shows a remnant of a former terrace now dissected into superb badlands and largely barren; also a low terrace covered mostly by wheat grass tall enough to mow. In the most thoroughly drained parts of the "flat," the short-grass association is replacing that of wheat grass.

The more conspicuous herbs other than grasses are perhaps³⁹ the annual *Eriogonum*, spiderwort, brome rape, *Allonia*, *Abronia*, the spurge, the showy *Gilia*, green milkweed, and three members of the *Caper* family. Legumes are numerous, lupine, prairie clovers, and the narrow-leaved *Psoraleas* being most numerous. The more common composites are the wormwood, the viscid aster, and *Franseria acanthicarpa*. The borders of the brooks, often quite gay with flowers, are not truly a part of the steppe.

Most of the animal life of sandy regions is associated with the springs and streams. The areas occupied by the typical sandhill vegetation have a sparse and not distinctive fauna so far as the larger animals are concerned. Of such typical portions the birds most abundant are the western vesper sparrow, lark bunting, and the western meadowlark. Sandy areas within the prairie region of Sanborn County, eastern South Dakota, form eastern outliers of the breeding range of the prairie sharp-tailed grouse. The mammals most frequently seen are the jackrabbit, the cottontail,⁴⁰ and the plains chipmunk. Because of the relative wildness of rough, sandy areas, they form retreats for wide-ranging mammals such as wolves and coyotes. Of the reptiles, the most abundant snake is the hog-nosed adder. The yellow-striped swift is plentiful in the more southern sandhills, and another lizard occurs, as does a land turtle. Several insects are abundant in sandy areas, including certain tiger beetles and the ant lion.

The sandhill areas of Nebraska and along the southern margin of South Dakota have an exceptionally varied flora and fauna. In addition to species of more general distribution, mentioned above, the following are abundant there:⁴¹ Hall's bunch grass, on the ridges; the southern sand-bur, the bush morning-glory, poison ivy, and dogwood. There are a few trees, especially the hackberry, cottonwood, and elm in depressions, or on the more stationary north-facing slopes. Among the herbs, the prickly poppy, sand thistle, *Froelichia campestris*, and a fourth representative of the *Caper* family are very conspicuous in season.

THE LOW SHRUB GROUP OF ASSOCIATIONS

This group of associations is represented in small areas, mostly by narrow bands, in the steppe formation. The buck-bush is a transition stage between grassland and woodland, and the sage brush between grassland and desert. Most of the area ordinarily classed as badlands belongs to the buffalo-grama

³⁹ The herbs referred to are: *Eriogonum annuum*; *Tradescantia occidentalis*; *Orobanche ludoviciana*; *Allonia linearis*, *A. nyctaginia*; *Abronia micrantha*; *Euphorbia hexagonum*, *E. Geyeri*; *Croton texensis*; *Gilia cephaloidea*; *Acerules viriflora linearis*; *Cleome lutea*, *C. serrulata*; *Polanisia trachysperma*; *Lupinus pusillus*; *Kuhniastera purpurea*, *K. villosa*, *K. alba*; *Psoralea lanceolata*, *P. tenuifolia*; *Ambrosia media*, *A. psilostachys*; *Machaeranthera sesilliflora*.

⁴⁰ The technical names of other animals mentioned in this paragraph are: *Sylvilagus nuttallii grangeri*; *Eutamias pallidus*; *Canis nubilus*, *C. latrans*, *C. n. nebrascensis*; *Heterodon nasicus*; *Sedoporus undulatus consobrinus*; *Cnemidophorus guttatus*; *Terrepenne ornata*; *Cincendula scutellaria*, *C. erubata*, *C. vermida*.

⁴¹ *Andropogon Hallii*, *Cnecrus carolinianus*, *Ipomoea leptophylla*, *Rhus Rydbergi*, *Cornus stolonifera riparia*, *Celtis occidentalis*, *Populus Sargentii*, *Ulmus americana*, *Argemone intermedia*, *Carduus plattensis*, *Cristatella Jamesii*.



FIG. 10.



FIG. 11.

FIG. 10—A butte whose top is sand. The dense vegetation on the sand is in striking contrast with the nearly barren clay slope below.

FIG. 11—The "gumbo-lily," a stemless evening primrose, is one of the few herbs that grow upon the almost barren badland areas.

and the wheat-grass associations. However, on the steeper slopes, the portion most distinctly "badland," almost the only vegetation consists of various shrubs (Fig. 8).

Buck-bush. The buck-bush, or wolfberry (*Symphoricarpus occidentalis*), a shrub which as a rule is about 16 inches tall, forms patches in and adjacent to groves along valleys throughout the Northern Great Plains. It is also found here and there on slopes, especially where soil moisture is plentiful, which more often is the case on north-facing than on other slopes. Even far from woodland, there are patches along flood-plains where the ground water is within reach. The buck-bush patches, many of which have a diameter of several rods, have, where dense, little value for pasturage and almost none for fodder. They are cut by the mower with difficulty, nor are they killed readily by plow or fire. Wild roses are common secondary species in these patches. The chief grasses, in most places very subordinate in importance, are blue-joint (*Andropogon furcatus*) and wild rye (*Elymus canadensis*).

There are no large animals restricted to these patches, though there are many nests of birds. In the steppe region, the prairie sharp-tailed grouse, long-billed curlew, upland plover, marsh and Swainson hawks, and other large birds, as well as western meadowlarks and Brewer's blackbirds often nest here. Cottontail rabbits and gophers (*Citellus tridecemlineatus*, *C. Franklini*) are at home here. Spiders are especially abundant.

Sage-brush. The true sage-brush (*Artemisia tridentata*) is represented very locally in South Dakota or North Dakota on silt along the lower terraces of some of the streams of the western part of these states, notably along the Little Missouri River, Sage Creek in Pennington County, and Indian Creek in Fall River County, the two last in southwestern South Dakota. It is somewhat more widespread in northwestern Nebraska. In these states it is a low shrub attaining less than half the height prevalent in more arid regions to the west. However, the number of individuals per square rod in many places is greater than farther west.

The lance-leaved sage (*Artemisia longifolia*, *A. filifolia*) is more widespread and is here a taller shrub, reaching a height of two or even two and a half feet. In the western third of South Dakota it occupies silty soil chiefly on terraces.

The vegetation between the clumps of sage in many places is dominated by patches of buffalo grass. Upon soil which is almost bare, the curious foliaceous lichen *Parmelia mollinscula* is abundant in many places. Clumps of prickly-pear cactus are conspicuous.

The most conspicuous bird characteristic of the sage-brush is the sage-hen, which was numerous here until a few years ago. It is being exterminated rapidly.

The most notable insect is the large black-and-white sage-moth, which is



FIG. 12.



FIG. 13.

FIG. 12—A view across the valley of the Teton, or Bad, River, showing part of Philip, S. D. Note the fine "bench," or "flat," just beyond the town.

FIG. 13—A "claim shanty" constructed chiefly of prairie sod.

very conspicuous for a few days in July and August. The larvae feed upon sage leaves.

Badlands. Badlands are developed in many places on clay in the Northern Great Plains; those in south-central South Dakota and in the Little Missouri Valley in North Dakota are especially extensive. Large sections of these badland areas are comparatively barren. Still larger portions are nearly level and grass covered (Fig. 9). The latter are discussed under the wheat-grass and buffalo-grama grass associations.

(a) *Conditions.* In regard to precipitation, these areas fare about the same as does the rest of the steppe. Their average temperature is probably greater because of the high percentage of slopes and partial protection from the wind. The whitish clay reflects the sunlight, resulting in a great intensity of light at times. During other hours of the day, a given spot may be in the shade. Shade can always be found along arroyos and behind steep-sided buttes. The rapidity of erosion in badlands, and the tendency of the clay to crumble and crack (Fig. 11), are two factors apparently very important in controlling vegetation. Another perhaps even more important factor is the inability of the materials to absorb or hold water. In the White River badlands there are some sandhills, and some of the badland buttes nearby are capped with sand. Erosion is evidently as rapid on such buttes as elsewhere, but a rank vegetation flourishes, apparently because of the water absorbed in the sand (Fig. 10).

(b) *Characteristic plants and animals.* In the more rugged badland areas, vegetation is scanty. Such as there is, is mainly shrubby and possesses long tap-roots. Various shrubby composites are especially conspicuous, especially the rabbit bush, *Gutierrezia Sarothrae*, *G. divaricata*, blue-aster, golden-aster, false bone-set, and several species of sage. Other plants are the gumbo-lily (Fig. 11), *Mentzelia*, salt bush, prickly pear, grease weed, and, locally, *Chenopodium Watsonii*. At the foot of the buttes, two annuals, the showy spurge, and thistle-tomato, frequently are found. Along the channels, the buffalo-berry forms many large thickets, and on the more shaded side of many buttes are clumps of western red cedar from which may be made good fence posts.⁴²

The badlands, because of their relative inaccessibility, are the home of several carnivores. Gray wolves and coyotes are more frequently met here than in the plains roundabout. Bobcats⁴³ are plentiful. The puma, or mountain lion, was formerly not rare. A few antelope still feed on some of

⁴² The scientific names of the above badland plants are: *Chrysothamnus graveolens*; *Senecio canus*; *Townsendia grandifolium*; *Chrysopsis hirsutissima*; *Khunia glutinosa*; *Artemisia filifolia*, *A. longifolia*, *A. frigida*; *Pachyophus caespitosa*, *P. macroglottis*, *P. montanus*; *Mentzelia decapetala*, *M. nuda*, *M. stricta*; *Atriplex Nuttallii*, *A. Suchlayana*, *A. argentea*; *Opuntia fragilis*; *Sarcobatus vermiculatus*; *Euphorbia marginata*; *Solanum rostratum*; *Lepargyrea (Shepherdia) argentea*; *Juniperus scopulorum*, *J. sabina*.

⁴³ The following are the technical names of the remaining mammals and reptiles mentioned: *Lynx rufus*; *Felis concolor*; *Antilocapra americana*; *Ovis canadensis auduboni*; *Odocoileus h. hemionus*; *Eutamias pallidus*; *Crotalus confluentus*; *Phrynosoma douglassii hermandesi*. A common bat is *Myotis californicus ciliobrum*.

the "flats." Bighorn sheep and mule deer formerly were common, and the bighorn may not yet be extinct in the White River badlands. The mammal now most frequently seen in badlands is the striped chipmunk. The chief birds are the rock wren, Say's phoebe, cliff swallow, violet green swallow, western lark sparrow, turkey buzzard, and prairie falcon. Rattlesnakes are not lacking, though far from common. The horned lizards ("toads") are seen occasionally.

(c) *The badland life* displays several peculiarities. The plants are mainly long-lived perennials, chiefly shrubby composites, and possess powerful tap and anchor roots and narrow and pubescent leaves. Such shrubs offer great resistance to erosion, undercutting, and slumping. They also are conservative, late-flowering, and present to cattle very little edible material. Nearly every species has yellow flowers. In addition to these perennials, there are various annuals which thrive during wet years on the moister alluvial flats.

The animals are grayish in color with the exception of the bats, swallows, and swifts. The crevices and cavelets furnish homes for the chipmunk, bat, bobcat, Say's phoebe, prairie falcon, and rock wren. The cliff swallow and white-throated swift find cliffs suitable for nesting sites. Several of the larger mammals, notably the bighorn sheep and mule or black-tailed deer, are powerful jumpers.

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